



The Role of Culturally Responsive Teaching (CRT) in Contextual Teaching and Learning to Improve Students' Scientific Explanation Skills



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Abstract

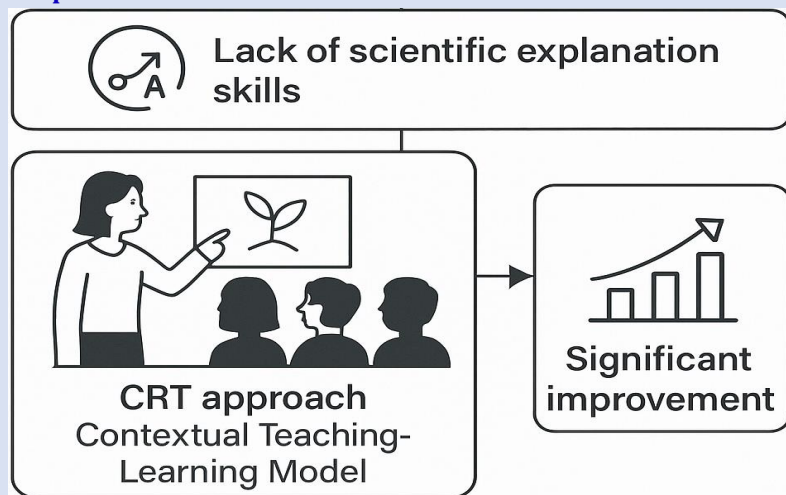
A scientific explanation is vital for students, but they often lack access to one. They seldom apply their knowledge to elucidate natural phenomena, leading to a basic and less meaningful understanding. To enhance students' abilities to provide scientific explanations, the culturally responsive teaching (CRT) approach is employed in science education. This pre-experimental pre-test post-test study involved seven students at a private junior high school in Malang. Written tests, including pre-tests and post-tests, were used to evaluate the improvement of students' scientific explanation skills. The study indicates a significant enhancement in students' scientific explanations, categorizing them in the medium range. This finding emphasizes the necessity to implement the CRT approach in broader educational contexts.

Keywords:

Argumentation Skill;
Scientific reasoning;
Local wisdom;

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Graphical Abstract



Introduction

Students' ability to provide scientific explanations is one of the essential 21st-century skills that must be cultivated through innovative learning. A scientific explanation is vital for students, as it enables them to construct scientific explanations of phenomena by supporting their claims with appropriate evidence and scientific principles. However, in practice, students still lack strong scientific explanation skills (Habiddin et al., 2021). They rarely apply their knowledge to clarify natural phenomena, resulting in a basic and less meaningful understanding. The ability of students to communicate scientific explanations is among the crucial skills of the 21st century that need to be developed through innovative learning methods. Scientific explanation involves generating claims that clarify phenomena by connecting scientific principles to existing evidence and justifying claims using appropriate evidence and scientific ideas (Sandoval & Reiser, 2004). Meanwhile, according to Chin & Brown (2000) scientific explanation is an explanation that refers to how or why a phenomenon occurs. A scientific explanation itself comprises three elements: claims, evidence, and reasons (McNeill et al., 2006; Wijayanto et al., 2020). Scientific explanations serve several purposes, including helping students understand and articulate a phenomenon with evidence, as well as persuading others to accept the strongest explanation of specific ideas (Wang, 2015).

The ability to construct scientific explanations is one of the essential skills in science learning, particularly at the junior high school level. Scientific explanations not only help students grasp concepts in depth but also encourage them to connect empirical evidence to relevant theories. This approach makes the learning process more meaningful, as students actively engage in constructing their understanding rather than merely memorizing information. Braaten & Windschitl (2011) stated that student participation in constructing scientific explanations contributes significantly to the formation of strong conceptual understanding, while positioning science as a dynamic investigative process. In line with that, McNeill & Krajcik (2008) the importance of teaching that directs students to construct scientific explanations systematically, through formulating claims, using supporting evidence, and scientific reasoning. Empirical support is also provided by Acebes & Taber (2024), who found that teaching strategies that emphasize explanation construction can improve the quality of student engagement and reasoning in science learning. Therefore, the integration of scientific explanations into the Indonesian Curriculum is highly relevant in promoting the development of 21st-century competencies and supporting the achievement of critical reasoning dimensions in the Pancasila Student Profile as mandated by the “Kurikulum Merdeka.”

However, in practice, students' ability to compile scientific explanations is still relatively low. Students rarely attribute their knowledge to explaining natural phenomena, so their understanding remains at a basic level and lacks deep conceptual meaning (Islakhiyah et al., 2018). Some students also tend to describe only what they observe instead of offering a causal explanation for why and how phenomena occur (Sampson et al., 2011). McNeill & Krajcik (2008) also revealed that students often face obstacles in presenting and defending their knowledge claims, particularly in connecting the allegations made with evidence that

logically and consistently supports them. Even in classroom settings where scientific explanations are a clear objective, students still face significant challenges. The quality of scientific explanations can be influenced by students' limited comprehension of scientific concepts or their ability to communicate these concepts effectively (Wang, 2015).

Based on the problems described, a meaningful and contextual learning approach is necessary. An innovative approach is required for training students' 21st-century skills (Nafiah et al., 2025). One alternative that can be implemented is the Contextual Teaching and Learning (CTL) model. CTL is a learning approach that emphasizes the link between teaching materials and students' real-life experiences (Trianto, 2007). The primary goal is to help students understand the meaning of learning materials by relating them to personal, social, and cultural contexts, enabling them to connect and apply the competencies gained in real-life situations. Through the application of these competencies in a daily context, students will feel the relevance of learning and gain a deeper understanding of the material they study. In this framework, learning is expected to be more meaningful (Ariawan et al., 2022). Additionally, the CTL model can be integrated with the Culturally Responsive Teaching (CRT) approach, as both emphasize the importance of local contexts, including cultural elements, in the learning process.

The CRT approach is a learning approach that emphasizes providing equal opportunities for all students to receive teaching regardless of their cultural background (Gay, 2000). This approach is particularly relevant in creating an inclusive learning environment and respecting students' cultural diversity. By taking into account students' cultural backgrounds and experiences, the CRT approach can enhance their engagement in learning and strengthen the connection between the subject matter and daily life. Integrating culture in the learning process will make the material more meaningful for students (Fadillah & Listiawan, 2024). Students will have an easier time understanding the material being studied because the material is related to contextually relevant events. This is in line with research conducted by Khasanah et al. (2023) which shows that the application of the CRT approach can improve student learning outcomes from various aspects, including cognitive, affective, and psychomotor. Sari et al. (2023) also revealed that integrating culture into learning can improve student learning outcomes when compared to conventional learning approaches. Therefore, combining the CTL model with the CRT approach is expected to enhance students' scientific explanation skills in science learning at the junior high school level.

Method

This study employs a pre-experimental design utilizing a pre-test and post-test model. In this study, the researcher will conduct two observations. The first observation occurs before the experiment, known as the pre-test, followed by the administration of the treatment. After this, a second observation takes place, referred to as the post-test. The results of these two observations will be compared through an analysis of the differences between pre-test and post-test results. This difference reflects the impact of the treatment administered during the

experiment. The data collection methods utilized in this study involve pre-test and post-test questionnaires. The pre-test and post-test questions are designed to assess students' scientific explanation skills, which encompass indicators of claims, evidence, and reasoning. This instrument aims to evaluate students' scientific explanation skills both before and after the treatment is applied.

This research was conducted at a private middle school in Malang, involving grade VII students, which included 7 students (5 male and 2 female). The study took place during the 2024/2025 academic year, focusing on learning materials related to the motion of the Earth in the solar system. It consisted of a learning cycle with two meetings. In the first meeting, the CTL model was applied. Students were given pre-test and post-test questions designed to assess their ability to explain scientific concepts. The indicators for scientific explanation being measured are presented in Table 1.

Table 1. Scientific Explanation Skill Indicator

Indicator	Description
Claim	a statement that will be tested and referred to as the answer to a scientific question (conclusion of a phenomenon)
Evidence	test or investigation data results to support the validity of claims.
Reasoning	Reports that justify claims by providing strong evidence showing why their data is considered evidence and how it is connected to the claim.

Results & Discussion

Learning activities took place in two meetings using an offline learning system for seventh-grade students at a private junior high school in Malang. The material covered was the solar system, with the implementation of the Contextual Teaching and Learning (CTL) model and the Culturally Responsive Teaching (CRT) approach as treatments for this study. In the first meeting, the subtopic discussed was the Earth's rotation and its effects. Before starting the core learning activities, students completed a pre-test. The learning session began with an introduction, followed by core activities that included the CTL model syntax, such as modeling (teacher as a model), inquiry, questioning, learning community, constructivism, reflection, and authentic assessment. It concluded with a closing session. Student activities included grasping the material, conducting investigations through direct experiments, discussing the Student Worksheet (LKPD), and engaging in question-and-answer sessions with the teacher and peers.

The learning process and student activities in the second meeting followed a pattern similar to the first. The difference lay in the topic and the practical activities conducted. In the second meeting, the material discussed was the Earth's revolution and its effects, during which students performed a simple simulation to illustrate this concept. After the lesson, the teacher asked the students to complete a 30-minute post-test. The implementation of the Culturally Responsive Teaching (CRT) approach during this meeting was achieved through the integration of local cultural content in the LKPD as a context for learning about Earth's rotation and revolution. Some of the cultural content included Malang folklore about the

shadow of Mount Arjuno as a time marker, the 'Farmer's Schedule' tradition based on the sun's position, the Tengger Suroan ceremony, and the traditional method of determining time using 'cow horns and mountain shadows.' Students' scientific explanation skills were analyzed by comparing pre-test and post-test scores, which were then calculated using the N-gain test to determine the level of improvement, as shown in Table 2.

Table 2. Pre-test and post-test analysis

Data	Pre-Test	Post-Test
Number of students	7	7
Lowest value	0	56
Highest score	48	81
Average score	10,3	71,4
N-Gain	0,68	
Criteria	Medium	

Based on the data in Table 2, the students' pre-test scores ranged from 0 to 48, with an average of 10.3. The post-test scores showed improvement, with the lowest score at 56, the highest at 81, and an average of 71.4. The average pre-test score remained below the Minimum Competency Criteria (KKM) standard for the school, which is 70. Conversely, the average post-test score exceeded the KKM threshold. This increase demonstrates that the combination of CTL and CRT effectively enhances students' understanding and explanation of scientific phenomena. This improvement was confirmed by the N-gain test analysis, which showed a value of 0.68, categorized as a moderate increase (Hake, 1998). The most noticeable improvement is seen in the ability to provide scientific evidence. Students can identify and relate phenomena in everyday life, such as changes in the shadow of Mount Arjuno or the tradition of 'farmers' schedules' based on the position of the sun, as a form of scientific evidence to explain the concept of the Earth's rotation and revolution. This illustrates the capacity to connect scientific concepts to their local cultural and environmental contexts, making learning more meaningful and applicable.

These findings align with previous studies, which have shown that applying the CTL model in science learning can improve student learning outcomes. This finding is also in line with the research of Laughter & Adams (2012), which asserts that culturally relevant science learning allows students to relate subject matter to their own experiences and backgrounds, thereby enhancing their ability to construct scientific explanations supported by evidence. Another study also confirmed that the CRT approach enhances student engagement and fosters a deeper conceptual understanding by connecting science material to students' cultural realities.

Sexton (2024) in his study in New Zealand, he also found that integrating local cultural narratives, such as Mātauranga Māori, into science learning helped students understand scientific concepts within their cultural context. This approach increased student engagement and understanding and encouraged them to build more meaningful scientific explanations. A similar study (Madkins & Royston, 2019), demonstrated that linking science learning to students' local experiences and knowledge, such as the use of medicinal plants in

botany lessons, can strengthen their scientific explanation competence. In addition, the basic theory of the culturally relevant learning approach proposed by Billings (1995) also underlies the success of this approach. He stated that cultural integration in learning can improve students' academic outcomes and conceptual understanding because students feel recognized and connected to the learning process. Thus, the integration of local cultural elements through the CRT approach in science learning has been shown to improve students' conceptual understanding and strengthen their ability to formulate scientific claims, present relevant evidence, and develop logical reasoning. These findings support the need for broader CRT implementation, especially in secondary education in Indonesia, which is rich in local cultural diversity.

Conclusion

This study found that applying the Culturally Responsive Teaching (CRT) approach within the Contextual Teaching and Learning (CTL) model effectively enhances students' abilities to explain scientific concepts. This finding suggests that linking science concepts to local cultural contexts encourages students to develop a more meaningful and applicable understanding of science. The implications for science teaching highlight the importance of teachers designing lessons that are not only contextual and relevant but also responsive to students' cultural backgrounds. Consequently, science instruction can become more inclusive, respect diversity, and promote the development of 21st-century scientific skills, including the ability to explain phenomena scientifically. However, the limited number of respondents hinders the generalization of this finding. Therefore, for future studies, it is recommended that the study's scope be broadened by involving a larger sample, testing the effectiveness of this approach in other subjects, and examining additional variables that may affect students' scientific explanation skills. Moreover, educators should consider integrating the CRT approach with the CTL model in their instruction as a strategy to enhance the quality of science teaching across various educational levels.

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